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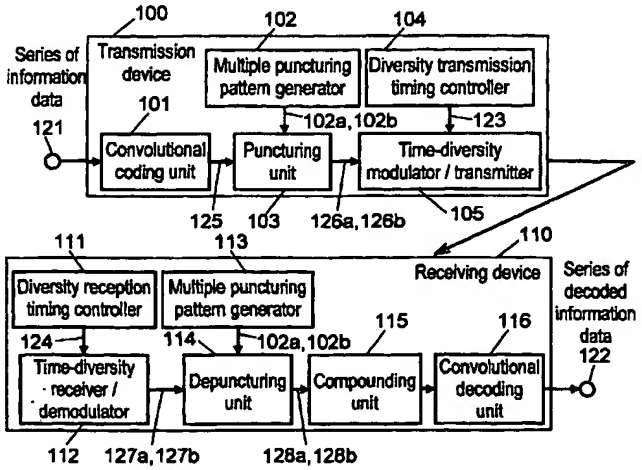
(54) Method and system for transmission and reception of punctured convolutionally encoded data

(57) The present invention improves quality of communication in a transmission and reception system, a transmission and reception device, and a method of transmission and reception, which utilize primarily a combination of punctured-convolution-coding and diversity. Degradation in likelihood of certain data is prevented by adopting the steps of (a) punctured-convolution-coding an identical information data 121 by using a plurality of different puncturing patterns 102a and 102b, (b) diversity-transmitting each of different series of punctured data obtained in step (a) as diversity branches, (c) depuncturing the series of punctured data individually in a receiving device 110 by using identical puncturing patterns 102a and 102b as used in the transmission side, and (d) compounding and convolution-decoding them thereafter.

FIG. 1A



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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a digital wireless transmission and reception system, a transmission and reception device, and a method of transmission and reception, in which quality of communication is improved.

BACKGROUND OF THE INVENTION

[0002] There are a number of methods for improving quality of communication in the digital wireless transmission such as an error-correction coding, a diversity transmission and reception, and a combination of them. A well-known method of error-correction coding among the above is a convolution coding having a superior performance in the error correction. One example is a newly devised method which combines interleaving and puncturing with the convolution coding, as disclosed in Japanese Patent Laid-Open Publication No. H08-298466. A method of the prior art for improving quality of communication using a combination of the convolution coding, the puncturing and the time-diversity will be briefly described by referring to Figs. 8A and 8B.

[0003] In a transmission device 800 of Fig. 8A, a series of information data 851 to be transmitted is punctured (thinning-out process) in a unit of a fixed amount of data block by a puncturing unit 802 in order to reduce an amount of communication traffic in a transmission pathway, after it is convolution-coded by a convolutional coding unit 801. A puncturing (thinning-out) location within the data block is stored as a puncturing pattern in a puncturing pattern generator 803, from where it is supplied to the puncturing unit 802.

[0004] An example shown in Fig. 8B will be described now in detail. A series of input information data {a0, b0, c0, d0, ...} is converted into a series of convolution-coded data {a1, a2, b1, b2, c1, c2, d1, d2, ...} by the convolutional coding unit 801 having a constraint length of 3 and a coding rate of 1/2. The puncturing unit 802 removes b2, d1, etc., and outputs a series of punctured data {a1, a2, b1, c1, c2, d2, ...}, when a puncturing pattern 803b is supplied from the puncturing pattern generator 803. This series of punctured data is a combination of a series of data {a1, b1, c1, e1, ...} which is obtained by deleting data corresponding to a 0 position in an upper row of the puncturing pattern 803b from a series of data {a1, b1, c1, d1, e1, ...} corresponding to the upper row of the pattern 803b out of the foregoing series of convolution-coded data, and another series of data {a2, c2, d2, e2, ...}, which is obtained by deleting data corresponding to a 0 position in a lower row of the pattern 803b from a series of data {a2, b2, c2, d2, e2, ...} corresponding to the lower row of the pattern 803b out of the series of convolution-coded data.

[0005] A time-diversity modulator / transmitter 804 repeats modulation and transmission of the series of punctured data for a predetermined number of times in response to a diversity transmission timing control signal supplied by a diversity transmission timing controller 805 at intervals of a predetermined time.

[0006] In a receiving device 810, the predetermined time for the transmission device 800 to repeat the time-diversity transmission is set in advance with a diversity reception timing controller 811, so that the controller 811 outputs a timing control signal for starting a time-diversity reception according to the set time. A time-diversity receiver / demodulator 812 receives and demodulates a signal transmitted repeatedly in response to the control signal of a time-diversity reception timing, and outputs a series of demodulated data of every diversity branch (every repeat time). In this example, description is being made on an assumption that a result of demodulation for each symbol in the series of demodulated data is a quantized data in a resolution of four bits, and a mark and a space have their respective values equivalent to -7 and +7 under the condition of no influence of noises.

[0007] A puncturing pattern generator 813 stores a puncturing pattern, which is identical to the puncturing pattern 803b used in the puncturing unit 802 of the transmission device. A depuncturing unit 814 uses this puncturing pattern to depuncture the series of demodulated data of every diversity branch, and outputs a series of depunctured data of every diversity branch. The depuncturing is a process in which the punctured position is filled with a dummy data such as a value of 0 corresponding to a middle value between the soft decision value of -7 corresponding to a mark and the soft decision value of +7 corresponding to a space, for example. In the case of the foregoing series of punctured data {a1, a2, b1, c1, c2, d2, ...}, the depuncturing unit 814 outputs a series of depunctured data {a1, a2, b1, 0, c1, c2, 0, d2, ...}.

[0008] The series of depunctured data of every diversity branch obtained here is compounded symbol by symbol in a unit of block by a compounding unit 815, and they are convolution-decoded with a method such as the Viterbi soft quantization by a convolutional decoding unit 816, which in turn outputs a series of decoded information data. There may be a case where the depuncturing and the compounding are reversed in their order of transaction.

[0009] The devices can thus achieve an improvement in quality of communication for both of the error-correction coding and diversity with the structure as described above, by performing punctured-convolution-coding and time-diversity transmission on the information data to be transmitted, and also compounding and depunctured-convolution-decoding after time-diversity reception of the data at the receiving side.

[0010] However, the structure of Figs. 8A and 8B punctures certain identical locations in the series of convolution-coded data (error-correction code word) in

each of the repeated transmissions by way of the time-diversity transmission. Therefore, these certain punctured locations and vicinity of them become susceptible to noises, as they become low in likelihood when convolution-decoding them, since they are treated as values having a large length between codes from both of the mark and the space at the receiving side.

SUMMARY OF THE INVENTION

[0011] The present invention is intended to solve the above problems and it aims at preventing a likelihood of certain information data from declining by adopting a different puncturing pattern for each of diversity branches when transmitting and receiving mainly information data by a combination of the punctured convolution-coding and the diversity, thereby improving quality of communication.

[0012] In order to avoid the foregoing problems, a transmission and reception system, a transmission and reception device, and a method of transmission and reception of the present invention comprise a transmission device, a receiving device, and a communication pathway between them. The transmission device includes the following elements:

(1) a convolutional coding unit for convolution-coding a series of input data, and outputting a series of convolution-coded data;
(2) a puncturing unit for puncturing the series of convolution-coded data by using a plural form of puncturing patterns individually, and outputting a plurality of series of punctured data; and
(3) a modulator / transmitter for modulating and transmitting the plurality of series of punctured data via at least one communication pathway. And the receiving device includes the following elements:

(1) a receiver / demodulator for receiving and demodulating a signal transmitted by the transmission device through the communication pathway, and outputting a plural variety of series of demodulated data;
(2) a depuncturing unit for depuncturing the plural variety of series of demodulated data by using each of the plural form of puncturing patterns that is identical to the one used by the puncturing unit, and outputting a plural variety of series of depunctured data;
(3) a compounding unit for compounding the plural variety of series of depunctured data, and outputting a result of compounding; and
(4) a convolutional decoding unit for convolution-decoding the result of compounding, and outputting a decoded data. Accordingly, the transmission and reception system, a transmission and reception device, and a method of transmission and reception are characterized by transmitting and receiving via at least one communication pathway each of the plural variety of series of error-correction coded data obtained by puncturing and convolution-coding the identical series of information data with the plural form of puncturing patterns.

[0013] Also, another transmission and reception system of the present invention comprises a transmission device and a receiving device, and that the transmission device includes the following elements:

(1) a convolutional coding unit for outputting a series of input data by convolution-coding them;
(2) a first multiple puncturing pattern generator for generating a predetermined plural form of puncturing patterns having an identical puncturing rate, but different in block pattern of puncturing with one another;
(3) a puncturing unit for puncturing the series of convolution-coded data by using each of the predetermined plural form of puncturing patterns supplied by the first multiple puncturing pattern generator, and outputting a predetermined plurality of different series of punctured data;
(4) a diversity transmission timing controller for outputting a diversity transmission timing control signal for carrying out transmission for a plural number of times at intervals of a predetermined time;
(5) a time-diversity modulator / transmitter for modulating and transmitting the predetermined plurality of different series of punctured data one by one as time-diversity transmission data at intervals of the predetermined time in response to the diversity transmission timing control signal. The receiving device includes the following elements:

(1) a diversity reception timing controller for outputting a predetermined diversity reception timing control signal for carrying out a reception of the signal transmitted with time-diversity transmission at intervals of the predetermined time;
(2) a time-diversity receiver / demodulator for receiving and demodulating each of the signals transmitted for a plural number of times by the transmission device in response to the diversity reception timing control signal, and outputting individual series of demodulated data;
(3) a second multiple puncturing pattern generator for generating puncturing patterns, which are identical to those generated by the first multiple puncturing pattern generator;
(4) a depuncturing unit for depuncturing each of the series of demodulated data in quantity corresponding to the predetermined number of diversity receptions output from the time-diversity receiver / demodulator by using the prede-

termined different form of puncturing patterns supplied from by the second multiple puncturing pattern generator, and outputting a plural number of series of depunctured data;

(5) a compounding unit for compounding the predetermined plural number of series of depunctured data output by the depuncturing unit, symbol by symbol in a unit of block, and outputting a result of compounding; and

(6) a convolutional decoding unit for convolution-decoding the result of compounding, and outputting a decoded data.

[0014] The transmission and reception system of the structure, as described above, executes the time-diversity transmission and reception of a plurality of different series of error-correction code word, as individual diversity branch data, by obtaining them through puncturing and convolution-coding the identical series of information data with different forms of puncturing patterns. Accordingly, the present invention is able to prevent a likelihood of certain information data from declining, and to further improve a quality of communication.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

Figs. 1A and 1B are drawings depicting block diagrams of a time-diversity transmission and reception system of a first exemplary embodiment of the present invention;

Figs. 2A, and 2B are drawings depicting a block diagram of a multiple puncturing pattern generator of a second exemplary embodiment of the present invention, and an example of generated puncturing patterns;

Fig. 3 is a drawing depicting a block diagram of a receiving device of a time-diversity transmission and reception system of a third exemplary embodiment of the present invention;

Fig. 4 is a drawing depicting a block diagram of a transmission and reception system of a fourth exemplary embodiment of the present invention;

Fig. 5 is a drawing depicting a block diagram of a transmission and reception system of a fifth exemplary embodiment of the present invention;

Fig. 6 is a drawing depicting a block diagram of a transmission and reception system of a sixth exemplary embodiment of the present invention;

Fig. 7 is a drawing depicting a block diagram of a satellite-path diversity transmission and reception system of a seventh exemplary embodiment of the present invention; and

Figs. 8A and 8B are drawings depicting block diagrams of an example of a time-diversity transmission and reception system of the prior art.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0016] The present invention relates to a transmission and reception system, a transmission and reception device and a method of transmission and reception, which realize an improvement in quality of communication by taking steps of:

(a) convolution-coding a data to be transmitted;

(b) producing a plurality of different series of punctured data by puncturing it in a unit of a predetermined block with a plural form of puncturing patterns; and

(c) transmitting each of the series of punctured data through a plurality of paths (diversity branches), and at a receiving side, by taking steps of:

(a) receiving and demodulating the signals through the plurality of paths (diversity branches);

(b) depuncturing the signals with puncturing patterns corresponding to them;

(c) compounding them from symbol to symbol in a unit of block; and

(d) reconstituting the original data by convolution-decoding them.

[0017] Exemplary embodiments of the present invention will be described hereinafter by referring to Fig. 1A through Fig. 7.

First Exemplary Embodiment

[0018] A first exemplary embodiment of the present invention relates to a time-diversity transmission and reception system for transmitting and receiving the above-cited plurality of different series of punctured data via a plurality of channels with carrier waves of the same frequency (same assigned range of frequency) but different in time (allotted time for transmission).

[0019] Fig. 1A depicts a structure of a time-diversity transmission and reception system of the first exemplary embodiment, and Fig. 1B is a drawing for use in describing an essential part of the same. A primary difference of the present structure from that shown in Figs. 8A and 8B as described in the prior art system is that the puncturing pattern generator provided in each of the transmission device and the receiving device for generating a single form of the puncturing pattern is replaced by a multiple puncturing pattern generator for generating a plurality of puncturing patterns in various forms. Although the present embodiment is an example in which transmission and reception are made via two channels in order to simplify the description, a number of channels can be expanded easily without impairing the universality.

[0020] First, a convolutional coding unit 101 convolu-

tion-codes a series of input information data 121, and outputs it as a series of convolution-coded data 125. The convolutional coding unit 101 in Fig. 1B is an example of circuit structure for convolution coding in a constraint length of 3 and a coding rate of 1/2.

[0021] On the other hand, a multiple puncturing pattern generator 102 generates two forms of puncturing patterns having an identical puncturing rate, but different in block pattern of puncturing with each other. For instance, it generates two different puncturing patterns, a pattern A, 102a, and a pattern B, 102b, both having a same puncturing rate of 17/22 (a number of bits after puncturing / a number of bits before the puncturing), as shown in Fig. 1B. In the figure, a numeral "0" indicates a location where the puncturing (thinning-out) is made within the puncturing patterns, and the puncturing locations are set in a manner that they do not overlap with each other between the patterns A and B.

[0022] A puncturing unit 103 punctures the series of convolution-coded data 125 by using the two puncturing patterns, the pattern A, 102a, and the pattern B, 102b, and outputs respective series of punctured data 126a and 126b.

[0023] Although the foregoing structure comprises the multiple puncturing pattern generator 102 and the puncturing unit 103 as being two separate blocks, the two functions can be combined into one block. In other words, the puncturing unit may have the function of generating plural forms of puncturing patterns as well as the function of puncturing.

[0024] A diversity transmission timing controller 104 outputs two orders of diversity transmission timing control signal 123 for the transmission device 100 to make time-diversity transmission at intervals of a predetermined time.

[0025] A time-diversity modulator / transmitter 105 carries out the time-diversity transmission twice in response to each of the two orders of diversity transmission timing control signal 123 delivered by the diversity transmission timing controller 104 by using the series of punctured data 126a for a first data of the time-diversity modulation and transmission and the series of punctured data 126b for a second data of the time-diversity modulation and transmission.

[0026] On the other hand, the predetermined time for the transmission device 100 to carry out the time-diversity transmission is set in advance with a diversity reception timing controller 111 of a receiving device 110, so that the controller 111 outputs a diversity reception timing control signal 124 twice on time for a start of time-diversity reception.

[0027] A time-diversity receiver / demodulator 112 receives and demodulates the time-diversity transmitted signal in response to the diversity reception timing control signal 124, and outputs two series of demodulated data 127a and 127b of every diversity branch.

[0028] A multiple puncturing pattern generator 113 generates two forms of puncturing patterns that are identical to those produced by the multiple puncturing pattern generator 102 of the transmission device 100.

[0029] A depuncturing unit 114 depunctures the series of demodulated data 127a and 127b by using the puncturing patterns 102a and 102b supplied by the multiple puncturing pattern generator 113, one after another, and outputs series of depunctured data 128a and 128b. In this depuncturing process, digital values in the series of demodulated data are output with their original values for unpunctured locations in the puncturing patterns, and a middle value between values of a mark and a space is inserted in each of the punctured locations. For instance, if individual symbols in the series of demodulated data are output in quantized soft decision values in a resolution of four bits, the mark and the space have values of -7 and +7 respectively, and a middle value between them corresponds to "0".

[0030] In the foregoing structure, although the multiple puncturing pattern generator 113 and the depuncturing unit 114 have been described as separate blocks, both of the functions can be combined into one block. For example, the depuncturing unit may have the function of generating two forms of puncturing patterns that are identical to those generated by the multiple puncturing pattern generator 102 of the transmission device 100, as well as the function of depuncturing.

[0031] A compounding unit 115 compounds the series of depunctured data 128a and 128b of every diversity branch, symbol by symbol in a unit of block. In the case of foregoing example, two 4 bits of digital data are added together. In the present exemplary embodiment, the addition of digital values in locations of the specific symbols does not leave the value "0" intact, since the locations where the value "0" is inserted in the depuncturing process differ between the two series of depunctured data 128a and 128b, as a matter of course. In the prior art techniques, on the other hand, a result of addition of digital values in certain symbols has left the value "0" unchanged after depuncturing, thereby causing the likelihood extremely low, since puncturing locations in blocks during the puncturing process have not varied, but remained same throughout time-diversity.

[0032] A convolutional decoding unit 116 decodes the series of compounded results output by the compounding unit 115 with a method such as the Viterbi soft quantization and the like means, and outputs a decoded series of information data 122.

[0033] As has been described, the present exemplary embodiment of this invention obtains two different series of punctured data by puncturing identical series of information data with two different forms of puncturing patterns, and executes time-diversity transmission of the obtained series of data as transmission data of individual time-diversity branches. A receiver compounds the transmitted data after depuncturing them by using two different forms of puncturing patterns, which are identical to those of the transmission side, and carries out convolution-decoding. In this way, the invention

prevents a reduction of likelihood from concentrating on certain information data, since the punctured locations differ between individual time-diversity branches, so as to improve quality of the communication.

[0034] Although the described embodiment is an example that uses two forms of puncturing patterns, this is not restrictive. A concept of the present exemplary embodiment is adaptable even to a structure, in which a number of puncturing patterns generated by the multiple puncturing pattern generator is increased to three forms or more, and a number of branches for the time-diversity transmission is increased to three or more, so long as these branches include different puncturing patterns.

[0035] Also, while the present exemplary embodiment as described above includes Fig. 1B showing an example of circuit structure for the convolution coding in a constraint length of 3 and a coding rate of 1/2, and describes the puncturing as being made in a puncturing rate of 17/22, they are not restrictive as it is needless to mention.

[0036] Further, although the puncturing locations are said to be not overlapping among the plurality of puncturing patterns in the described embodiment, this is not restrictive, as some of the puncturing locations may overlap.

[0037] Moreover, it goes without mentioning that the system can be constructed in a manner that the convolutional coding unit is supplied with a series of data processed by other error-correction coding or error-detection coding as the series of information data. Or, the system may comprise a processing unit for interleaving and/or another unit for composing a burst, inserted between the puncturing unit and the modulator / transmitter.

Second Exemplary Embodiment

[0038] A second exemplary embodiment relates to an improvement of the multiple puncturing pattern generator in the time-diversity transmission and reception system of the first exemplary embodiment. The present system produces a reference matrix for generating a puncturing pattern at first, and generates plural forms of puncturing patterns by converting the reference matrix.

[0039] Fig. 2A shows an internal structure of a multiple puncturing pattern generator (corresponding to the generators 102 and 113 in Figs. 1A and 1B) of the second exemplary embodiment. In Fig. 2A, a reference matrix generator 201 is for generating a matrix for use as a reference when generating a plurality of puncturing patterns, and a matrix 201a is an example of the reference matrix generated by it.

[0040] A matrix converter 202 outputs a plurality of puncturing patterns by converting a row, a column or matrix elements of the reference matrix 201a according to a predetermined process. In the example of Fig. 2A, the matrix converter 202 outputs two forms of puncturing patterns 202a and 202b by exchanging rows in the reference matrix 201a. That is, the multiple puncturing pattern generator 102 first generates a matrix data from the reference matrix 201a without exchanging any of the rows, and outputs it as the puncturing pattern 202a. It then exchanges between a first row and a second row of the reference matrix 201a, and outputs it as the puncturing pattern 202b. The structure and function of the time-diversity transmission and reception system of the second exemplary embodiment, other than the foregoing, remain the same as those of Figs. 1A and 1B.

[0041] With the present exemplary embodiment as described above, the system is able to save a memory capacity as compared to the system of the first exemplary embodiment, since it stores only one matrix as a reference for the multiple puncturing pattern generator to generate a plurality of puncturing patterns.

[0042] Although in the foregoing description of Fig. 2A in the present exemplary embodiment, the matrix converter adopts a method for exchanging matrix elements in rows of the reference matrix, this is not restrictive, and it may use a method of generating a plurality of puncturing patterns by exchanging column by column, as shown in Fig. 2B. There are also other methods of generating a plurality of puncturing patterns such as one that combines a plurality of rows in a predetermined order.

Third Exemplary Embodiment

[0043] A third exemplary embodiment relates to an improvement of the compounding unit in the time-diversity transmission and reception system of the first exemplary embodiment. The present system obtains a result of compounding by weighting a series of depunctured data according to a level of receiving signal, and adding it symbol by symbol.

[0044] Fig. 3 shows a structure of a receiving device 310 in a time-diversity transmission and reception system of the third exemplary embodiment. A reception level memory 301 measures a level of receiving signal at a time-diversity receiver / demodulator 112 in response to a diversity reception timing control signal supplied by a diversity reception timing controller 111, and stores a result of the measurement for every diversity branch. In this example, the reception level memory 301 stores reception levels R1 and R2 for each of the time-diversity signals transmitted twice.

[0045] A weighting / compounding unit 302 weights a series of depunctured data of every diversity branches delivered from a depuncturing unit 114 according to the reception level stored in the reception level memory 301, and compounds it thereafter, symbol by symbol in a unit of data block. If weighting factors for each of the two diversity branches obtained according to magnitudes of the reception levels R1 and R2 are denoted by W1 and W2, and digital values at number "i" in order of succession in the block of each series of punctured data

by d1i and d2i, then a weighted-and-compounded result "di" can be expressed by the following formula:

$$di = (W1 \times d1i + W2 \times d2i) / (W1 + W2)$$

[0046] The structure and function of the time-diversity transmission and reception system of this exemplary embodiment, other than the foregoing, remain the same as those of Figs. 1A and 1B.

[0047] In this embodiment, it is assumed that a magnitude of weighting is classified into three steps of "large", "medium" and "small" according to the reception level with their respective weighting factors of "1", "1/2" and "1/4", and the reception levels R1 and R2 are of magnitudes corresponding to "large" and "medium" respectively. In this instance, a weighting factor W1 for the first diversity branch becomes "1", and a weighting factor W2 for the second diversity branch becomes "1/2" at the weighting / compounding unit 302. If the series of depunctured data for two diversity branches supplied from the depuncturing unit 114 are assumed to be d1 = {5, 7, -6, 0, -7 .....} and d2 = {3, -2, 0, 4, -7 .....} respectively, a series of data "d" obtained as a result of compounding is d = {4.3, 4, -4, 1.3, -7 .....}, so that these data are supplied to a convolutional decoding unit 116.

[0048] Accordingly, the present exemplary embodiment of the invention is expected to achieve an effectiveness equivalent to the maximum-ratio combining diversity, since it compounds depunctured data after weighting the data according to reception levels for each diversity branch of the received time-diversity signal, when compounding the depunctured data.

[0049] Although the foregoing example of the present exemplary embodiment has chosen a three-step classification for reception level with respective weighting factors of "1", "1/2" and "1/4", this is not exclusive. The classification can be set for any number of steps, and the weighting factors can be of any values so long as they correspond with the reception levels.

[0050] Also, while the foregoing exemplary embodiment has made the proportional compounding calculations to include a decimal fraction in the weighting / compounding unit 302, this is not restrictive, and integral calculation may be made without regarding decimal fraction.

Fourth Exemplary Embodiment

[0051] A fourth exemplary embodiment relates to a code division multiplex signal transmission and reception system for transmitting and receiving the above-cited plurality of different series of punctured data with a plurality of channels for code division multiplex signal.

[0052] Fig. 4 shows a structure of a transmission and reception system of the fourth exemplary embodiment. The system of Fig. 4 is provided with a code division multiplex signal transmitter 401 for code-division-multiplexing and transmitting a predetermined plural number of series of punctured data fed in it, in place of the diversity transmission timing controller 104 and the time-diversity modulator / transmitter 105 in the transmission device of Fig. 1A. The system is also provided with a code division multiplex signal receiver 402 for receiving and demodulating individual signals transmitted with code-division-multiplexing and outputting a series of demodulated data, in place of the diversity reception timing controller 111 and the time-diversity receiver / demodulator 112 in the receiving device 110 of Fig. 1A.

[0053] The transmission and reception system constituted as above will be described hereinafter for the portions that operate differently from that of the first exemplary embodiment. The transmission device 400 transmits a plural variety of punctured data series output from a puncturing unit 103 after they are code-division-multiplexed and spread-modulated by the code division multiplex signal transmitter 401. The receiving device 410 receives the transmitted signals multiplexed by code-division multiplexing, demodulates each of the multiplexed signals with a despreading process by the code division multiplex signal receiver 402, and supplies a predetermined plural number of series of demodulated data to a depuncturing unit 114. All other operations are same as those of Figs. 1A and 1B.

[0054] As described, this exemplary embodiment of the present invention enables the system to improve quality of communication in the like manner as the one using time-diversity transmission and reception, since it carries out transmission and reception of a plurality of different series of punctured and convolution-coded data with the code division multiplexing instead of the time-diversity transmission and reception.

Fifth Exemplary Embodiment

[0055] A fifth exemplary embodiment relates to a path-diversity transmission and reception system, in which a plurality of transmission devices transmits the above-described plurality of different series of punctured data via a plurality of channels, and a receiving device receives the same.

[0056] Fig. 5 shows a structure of a transmission and reception system of the fifth exemplary embodiment. A space-diversity transmission system comprises two units of transmission devices 500a and 500b for processing and modulating identical series of information data, and transmitting them in a manner to avoid overlapping in time.

[0057] A puncturing pattern generator in each of the transmission devices is adapted to generate a puncturing pattern having the same puncturing rate but in a different form from each other. A puncturing pattern generator 502a generates a puncturing pattern that is identical to the pattern 102a in Fig. 1B, and a puncturing pattern generator 502b generates a puncturing pattern identical to the pattern 102b in the same figure.

[0058] Convolutional coding units 501a and 501b in

the two transmission devices convolution-code a series of information data 521 fed in them, and output series of convolution-coded data. In the transmission device 500a, a puncturing unit 503a punctures the obtained series of convolution-coded data by using the puncturing pattern A, 102a, of Fig. 1B supplied from the puncturing pattern generator 502a. And, a puncturing unit 503b in the transmission device 500b punctures the obtained series of convolution-coded data by using the puncturing pattern B, 102b, of Fig. 1B supplied from the puncturing pattern generator 502b. Modulator / transmitters 505a and 505b modulate and transmit the series of punctured data obtained in the foregoing puncturing units according to information for transmission timings and transmission frequencies supplied from transmission controllers 504a and 504b in the individual transmission devices. Each of the signals transmitted by the transmission devices 500a and 500b has approximately same frequency, and is so arranged not to overlap in transmission timing with each other.

[0059] A receiving device 510 receives and demodulates the signals transmitted by the two transmission devices 500a and 500b according to information for a predetermined reception timing and a receiving frequency supplied from a reception controller 511, and outputs respective series of demodulated data.

[0060] A depuncturing unit 114 depunctures the series of demodulated data of the signal transmitted by the transmission device 500a with a puncturing pattern, which is identical to the pattern 102a generated by the puncturing pattern generator 502a, out of the two predetermined forms of different puncturing patterns supplied by a multiple puncturing pattern generator 113, and the series of demodulated data of the signal transmitted by the transmission device 500b with a puncturing pattern that is identical to the pattern 102b generated by the puncturing pattern generator 502b, and outputs respective series of depunctured data.

[0061] Following the above, a compounding unit 115 compounds a plural series of the depunctured data delivered from the depuncturing unit 114, symbol by symbol in a unit of block. A convolutional decoding unit 516 then convolution-decodes the obtained series of compounded results, and outputs a series of decoded information data 522.

[0062] With the present exemplary embodiment of this invention, as described above, when transmitting identical series of information data with a plurality of transmission devices, the transmission devices transmit the identical series of information data after puncturing and convolution-coding each of the data series with a different puncturing pattern among the transmission devices. A receiving device depunctures the signals transmitted by each of the transmission devices with the identical patterns that are used by the transmission devices. In this way, the invention is able to vary puncturing locations from one transmission device to another, so as to avoid a reduction in likelihood of certain information data, and to further improve quality of the communication.

[0063] Although the transmission controllers 504a and 504b in the present exemplary embodiment are so arranged that frequencies of transmission from the transmission devices are approximately equal, and their transmission timings do not overlap with each other, these are not restrictive. Instead, the frequencies of transmission from the transmission devices may be arranged so as not to overlap with each other, while maintaining the transmission timings approximately equal between the transmission devices. Or, both of the transmission timings and the frequencies of transmission can be arranged not to overlap between the transmission devices. In these cases, information for reception timings and receiving frequencies need to be set with the reception controller 511 according to the information of the transmission side.

[0064] Also, the transmission devices may be provided with code-division multiplex signal transmitters, instead of the modulator / transmitters 505a and 505b in the transmission devices, for modulating and transmitting the series of punctured data with code-division multiplexing according to information for transmission timing and transmission frequency, while maintaining the transmission timings and the transmission frequencies set by the transmission controllers 504a and 504b in the transmission devices approximately equal. At the same time, the receiving device comprises a code-division multiplex signal receiver, instead of the receiver / demodulator 512, for outputting a series of demodulated data by receiving and demodulating every signals transmitted with code-division multiplexing from the transmission devices by way of extracting them with the despreading process, while maintaining the reception timings and the reception frequencies set with the reception controller 511 for the signals transmitted by the transmission devices approximately equal. Hence a system can be constituted with a plurality of transmission devices for transmitting identical series of information data by code-division multiplexing, and a receiving device for receiving and demodulating every code-division multiplexed signals.

[0065] In addition, although the system of the present exemplary embodiment is provided with two transmission devices, this is not exclusive and three or more transmission devices can be provided, as long as puncturing patterns used by the individual transmission devices are generated in different varieties, and a multiple puncturing pattern generator in the receiving device is adapted to generate every one of these patterns. Moreover, although both of the transmission devices independently perform the entire operation between input and transmission of the series of information data, an operation common to both devices may be made together by providing an input processing unit for processing input data.

Sixth Exemplary Embodiment

[0066] A sixth exemplary embodiment relates to a time and space diversity transmission and reception system, which transmits the above-described plurality of different series of punctured data via a plurality of channels with a same carrier wave but different in time, and receives with a plurality of receiving devices.

[0067] Fig. 6 shows a structure of a transmission and reception system of the sixth exemplary embodiment. A time and space diversity transmission and reception system comprises a transmission device 600 for transmitting a signal, and two units of receiving devices 610a and 610b for performing a process of receiving and demodulating the signal. In Fig. 6, the transmission device 600 is provided with a transmission controller 601 and a modulator / transmitter 602 in place of the diversity transmission timing controller 104 and the time-diversity modulator / transmitter 105 in the transmission device 100 of Figs. 1A and 1B. In the transmission device 600, an operation is carried out in the same manner as the transmission device 100 of the first exemplary embodiment between a process of convolution-coding the series of information data being transmitted and a process of puncturing them into two different series of punctured data by using two different puncturing patterns A, 102a, and B, 102b shown in Fig. 1B.

[0068] The modulator / transmitter 602 modulates and transmits one of the two different series of punctured data obtained with the puncturing pattern A, 102a, of Fig. 1B toward the receiving device 610a according to information of a predetermined transmission timing and transmission frequency for the receiving device 610a supplied from the transmission controller 601. The modulator / transmitter 602 also modulates and transmits another series of data punctured with the puncturing pattern B, 102b, of Fig. 1B toward the receiving device 610b according to the information of a predetermined transmission timing and transmission frequency for the reception device 610b supplied from the transmission controller 601. An arrangement is made in advance so that the transmission timings set for the two series of punctured data do not overlap with each other, and the transmission frequencies are approximately same.

[0069] The two units of receiving devices 610a and 610b receive and demodulate the signals transmitted to them from the transmission device 600 according to the information for transmission timings and transmission frequencies supplied by their respective reception controllers 611a and 611b, and output respective series of demodulated data.

[0070] In the receiving devices 610a, a depuncturing unit 614a depunctures the series of demodulated data by using the puncturing pattern A, 102a, supplied from a puncturing pattern generator 613a, and outputs a series of depunctured data 633a.

[0071] In the receiving devices 610b, on the other hand, a depuncturing unit 614b depunctures the series of demodulated data by using the puncturing pattern B, 102b, supplied from a puncturing pattern generator 613b, and outputs a series of depunctured data 633b.

[0072] An output processing device 620 accumulates the series of depunctured data 633a and 633b supplied from both of the receiving devices, and a compounding unit 621 compounds them symbol by symbol in a unit of block. Then, a convolutional decoding unit 622 convolution-decodes the compounded result, and outputs a series of decoded information data 632.

[0073] As has been described, the foregoing exemplary embodiment of the present invention punctures and convolution-codes a series of information data with different puncturing patterns for every transmission to the individual receiving devices when transmitting identical series of information data to the plurality of the receiving devices, thereby enabling the system to vary puncturing locations for every transmission to the individual receiving devices, prevent a degradation in likelihood of certain information data, and further improve quality of communication.

[0074] Although the transmission controller 601 in the present exemplary embodiment is so arranged in advance that transmission frequencies to the individual receiving devices are approximately equal, and their transmission timings do not overlap with each other, these are not restrictive. Instead, the transmission frequencies to the individual receiving devices may be arranged so as not to overlap between the transmissions, while maintaining the transmission timings approximately equal. Or, both of the transmission timings and the transmission frequencies can be arranged not to overlap between the transmissions to the receiving devices. In these cases, information for reception timings and receiving frequencies are to be set with the reception controllers 611a and 611b in the individual receiving devices according to information of the transmission side.

[0075] Also, the transmission devices may be provided with a code-division multiplex signal transmitter, instead of the modulator / transmitters 602, for modulating and transmitting the plurality of punctured data series with code-division multiplexing, while maintaining the transmission timings and the transmission frequencies of the transmission controller 601 approximately equal. At the same time, each of the receiving devices may comprise a code-division multiplex signal receiver, instead of the receiver / demodulators 612a and 612b, for outputting series of demodulated data by receiving and demodulating a specific signal addressed to the individual receiving devices out of the signals transmitted with code-division multiplexing from the transmission device by way of extracting it with the despreading process, while setting the reception timings and the receiving frequencies approximately equal between the reception controllers 611a and 611b. Hence the system can be constituted with a transmission device for trans-

mitting identical series of information data by code-division multiplexing to a plurality of receiving devices, and the receiving devices for receiving and demodulating the code-division multiplexed signals.

[0076] Furthermore, each receiving device may be provided with a reception level measuring unit for measuring individual signal levels received by the receiver / demodulator 612a or 612b according to information for the transmission timing and the transmission frequency supplied by the reception controller 611a or 611b, and outputting a result of the measurements. Also, the output processing device 620 may be provided with a weighting / compounding unit, instead of the compounding unit 621, for weighting and compounding the individual series of depunctured data based on the signal reception levels supplied by the individual receiving devices in order to gain an effectiveness equivalent to the maximum-ratio compound diversity, in the same manner as the third exemplary embodiment.

[0077] Although the system of the described embodiment is provided with two receiving devices, this is not exclusive and three or more receiving devices may be provided, if puncturing patterns to be used for puncturing during transmission to the individual receiving devices are generated in different varieties, and a multiple puncturing pattern generator in the transmission device is adapted to generate every one of these patterns.

Seventh Exemplary Embodiment

[0078] A seventh exemplary embodiment relates to a satellite-path diversity transmission and reception system, in which a transmission device transmits the above-described plurality of different series of punctured data via a plurality of channels with same carrier wave but different in time, and a receiving device receives them via a plurality of satellite repeater stations.

[0079] Fig. 7 shows a structure of a satellite-path diversity transmission and reception system of the seventh exemplary embodiment. Satellite repeater stations 700a and 700b relay transmission signals from an earth station transmission device 710 to an earth station receiving device720. The earth station transmission device 710 is provided with an earth station modulator / transmitter 711 in place of the diversity transmission timing controller 104 and the time-diversity modulator / transmitter 105 in the transmission device100 of Figs. 1A and 1B. All other structure and operation remain same as the transmission device100 of Figs. 1A and 1B.

[0080] Also, the earth station receiving device 720 is provided with an earth station receiver / demodulator 721 in place of the diversity reception timing controller 111 and the time-diversity receiver / demodulator 112 in the receiving device110 of Figs. 1A and 1B. All other structure and operation remain same as the receiving device110 of Figs. 1A and 1B.

[0081] The satellite-path diversity transmission and reception system constructed as above operates in a manner, which will be described hereinafter. In the earth station transmission device 710, a convolutional coding unit 101 convolution-codes identical series of information data at first. A puncturing unit 103 punctures the series of obtained convolution-coded data by using each of two forms of puncturing patterns A, 102a, and B, 102b, shown in Fig. 1B, supplied from a multiple puncturing pattern generator 102, and outputs two series of punctured data.

[0082] The earth station modulator / transmitter 711 modulates and transmits a series of data punctured with the puncturing pattern A, 102a, out of the two series of punctured data supplied from the puncturing unit 103 toward the satellite repeater station 700a. The earth station modulator / transmitter 711 also modulates and transmits another series of data punctured with the puncturing pattern B, 102b, toward the satellite repeater station 700b.

[0083] The earth station receiver / demodulator 721 in the earth station receiving device 720 receives and demodulates individual transmission signals relayed via the satellite repeater stations 700a and 700b, and outputs two varieties of demodulated data series.

[0084] A depuncturing unit 114 depunctures the series of demodulated data derived from a signal of the satellite repeater station 700a, out of the two series of demodulated data supplied from the earth station receiver / demodulator 721, by using a puncturing pattern, which is identical to the puncturing pattern A, 102a, supplied by a multiple puncturing pattern generator 113. The depuncturing unit 114 also depunctures another series of demodulated data derived from a signal of the satellite repeater station 700b by using a puncturing pattern that is identical to the puncturing pattern B, 102b, supplied by the multiple puncturing pattern generator 113.

[0085] A compounding unit 115 compounds the two varieties of depunctured data series obtained here from symbol to symbol in a unit of block. Then, a convolutional decoding unit 116 convolution-decodes the compounded result, and outputs a series of decoded information data 732.

[0086] With the present exemplary embodiment of this invention, as has been described, the earth station transmission device punctures identical series of information data by using a plurality of different puncturing patterns, and executes a satellite-path diversity transmission of the different series of obtained punctured data to a plurality of satellites as transmission data for individual satellite-path diversity branches. The earth station receiving device depunctures the transmission data by using a plurality of different puncturing patterns, which are identical to those of the transmission side, compounds and convolution-decodes thereafter. In this way, the invention is able to avoid a degradation in likelihood of certain information data, and to further

improve quality of the communication.

[0087] Although the present exemplary embodiment has a structure for making a unidirectional communication from the earth station transmission device to the earth station receiving device, this is not restrictive. In a system comprising a plurality of earth stations for performing a path-diversity transmission and reception via a plurality of satellite repeater stations, for example, each of the earth stations may comprise both of an earth station transmission device 710 and an earth station receiving device 720.

[0088] Although the system of the described embodiment is adapted to use two satellite repeater stations, this is not exclusive and three or more repeater stations can be used as is evident from the other exemplary embodiments.

[0089] Again, although the foregoing first, fourth, fifth and sixth exemplary embodiments are systems that make one-way communication from transmission devices to receiving devices, they can be systems that make bi-directional communication between two transmission / reception devices having a combined function of both transmission device and receiving device and sharing common functional components between them.

[0090] Although the transmission device in each of the foregoing exemplary embodiments has been described as having a (multiple) puncturing pattern generator and a puncturing unit as separate blocks, they can be combined into one block. For example, the puncturing unit may be adapted to generate a (or plural forms of) puncturing pattern(s), and carry out puncturing also. In the same manner, the receiving device has been described as having a (multiple) puncturing pattern generator and a depuncturing unit as separate blocks, they can be combined also into one block. For example, the depuncturing unit may be adapted to generate a (or plural forms of) puncturing pattern(s) identical to the (plural forms of) puncturing pattern(s) generated by the (multiple) puncturing pattern generator of the transmission device, and carry out depuncturing.

[0091] Accordingly, a system of the present invention convolution-codes series of information data by using puncturing patterns, which differ from one diversity branch to another, when transmitting and receiving primarily the series of information data with a combination of punctured-convolution-coding and diversity, thereby preventing a degradation in likelihood of certain information data, and achieving a remarkable improvement in quality of communication.

Claims

1. A transmission and reception system comprising a transmission device, a receiving device, and a communication pathway between said transmission device and said receiving device, said transmission device comprising:

   (1) a convolutional coding means for convolution-coding a series of input data, and outputting a series of convolution-coded data;

   (2) a puncturing means for puncturing said series of convolution-coded data by using a plural form of puncturing patterns individually, and outputting a plurality of series of punctured data; and

   (3) a modulation / transmission means for modulating and transmitting said plurality of series of punctured data via at least one communication pathway, and

   said receiving device comprising:

   (1) a reception / demodulation means for receiving and demodulating a signal transmitted by said transmission device via said communication pathway, and outputting a plural variety of series of demodulated data;

   (2) a depuncturing means for depuncturing said plural variety of series of demodulated data by using puncturing patterns that are identical to said plural form of puncturing patterns used by said puncturing means, and outputting a plural variety of series of depunctured data;

   (3) a compounding means for compounding said plural variety of series of depunctured data, and outputting a result of compounding; and

   (4) a convolutional decoding means for convolution-decoding said result of compounding, and outputting a decoded data,

   wherein said transmission and reception system transmits and receives via said at least one communication pathway each of a plural variety of series of error-correction coded data words obtained by punctured-convolution-coding identical series of information data with said plural form of puncturing patterns.

2. A time-diversity transmission and reception system according to claim 1 comprising a transmission device and a receiving device, said transmission device comprising:

   (1) a first convolutional coding means for outputting a series of input data by convolution-coding said series of data;

   (2) a first multiple puncturing pattern generation means for generating a predetermined plural form of puncturing patterns having an identical puncturing rate, but different in block pattern of puncturing with one another;

   (3) a first puncturing means for puncturing a series of convolution-coded data output by said

first convolutional coding means by using each of said predetermined plural form of puncturing patterns supplied by said first multiple puncturing pattern generation means, and outputting a predetermined plurality of different series of punctured data;

(4) a diversity transmission timing control means for outputting a diversity transmission timing control signal for carrying out transmission for a plural number of times at intervals of a predetermined time;

(5) a time-diversity modulation / transmission means for modulating and transmitting, as time-diversity transmission data, said predetermined plurality of different series of punctured data output by said first puncturing means one by one at intervals of the predetermined time in response to said diversity transmission timing control signal, and

said receiving device comprising:

(1) a diversity reception timing control means for outputting a predetermined diversity reception timing control signal for carrying out reception of a signal transmitted with time diversity transmission at intervals of said predetermined time;

(2) a time-diversity reception / demodulation means for receiving and demodulating each of the signals transmitted for a plural number of times by said transmission device, in response to said diversity reception timing control signal, and outputting individual series of demodulated data;

(3) a second multiple puncturing pattern generation means for generating puncturing patterns, which are identical to the predetermined plural form of puncturing patterns generated by said first multiple puncturing pattern generation means;

(4) a first depuncturing means for depuncturing each of the series of demodulated data in quantity corresponding to the predetermined number of diversity receptions output from said time-diversity reception / demodulation means by using the predetermined different form of puncturing patterns supplied by said second multiple puncturing pattern generation means, and outputting a plural number of series of depunctured data;

(5) a first compounding means for compounding the predetermined plural number of series of depunctured data output by said first depuncturing means, symbol by symbol in a unit of block, and outputting a result of compounding; and

(6) a first convolutional decoding means for convolution-decoding said result of compounding, and outputting a decoded data,

wherein said time-diversity transmission and reception system executes time-diversity transmission and reception of a plurality of different series of error-correction code word, as individual diversity branch data, obtained by puncturing and convolution-coding identical series of information data with the plurality of different forms of puncturing patterns.

3. The time-diversity transmission and reception system according to claim 2, wherein:

(1) said series of demodulated data output by said time-diversity reception / demodulation means are digital values quantized with a predetermined number of bits;

(2) said depuncturing on punctured locations carried out by said first depuncturing means is a process of inserting a middle value between two digital values corresponding to a mark and a space;

(3) said compounding by said first compounding means is a process of addition of a digital value to said series of depunctured data in the predetermined plural number output by said first depuncturing means, symbol by symbol in a unit of block; and

(4) said first convolutional decoding means defines Viterbi soft quantization means for executing Viterbi soft decision.

4. The time-diversity transmission and reception system according to claim 2, wherein puncturing locations in said predetermined plural form of puncturing patterns generated by said first multiple puncturing pattern generation means are set in advance in a manner not to overlap among said plurality of patterns.

5. The time-diversity transmission and reception system according to claim 2, wherein said first multiple puncturing pattern generation means comprises a first reference matrix generation means for generating a reference matrix of puncturing pattern, and a first matrix conversion means for outputting a different puncturing pattern for each diversity branch by converting any one or more of rows, columns and elements of said reference matrix.

6. The time-diversity transmission and reception system according to claim 5, wherein said second multiple puncturing pattern generation means comprises a second reference matrix generation means having the same function as said first reference matrix generation means, and a second

matrix conversion means having the same function as said first matrix conversion means with relation to a reference matrix generated by said second reference matrix generation means.

7. The time-diversity transmission and reception system according to claim 2, further comprising:

(1) a reception level memory means for measuring a reception level at every timing of diversity reception in said time-diversity reception / demodulation means, and storing a result of measurement; and
(2) a weighting / compounding means, replacing said first compounding means, for compounding after weighting the series of depunctured data of a predetermined number of times output by said first depuncturing means according to the reception level for each of every diversity branches stored in said reception level memory means, and outputting a result of compounding.

8. A time-diversity transmission and reception system according to claim 1, comprising a transmission device and a receiving device, said transmission device comprising:

(1) a first convolutional coding means for outputting a series of input data by convolution-coding said series of data;
(2) a first multiple puncturing pattern generation means for generating a predetermined plural form of puncturing patterns having an identical puncturing rate, but different in block pattern of puncturing with one another;
(3) a first puncturing means for puncturing a series of convolution-coded data output by said first convolutional coding means by using each of said predetermined plural form of puncturing patterns supplied by said first multiple puncturing pattern generation means, and outputting a predetermined plurality of different series of punctured data;
(4) a first code division multiplex signal transmission means for transmitting said predetermined plurality of different series of punctured data by code division multiplexing simultaneously, and
said receiving device comprising:

(1) a first code division multiplex signal reception means for receiving and demodulating a signal transmitted with said code division multiplexing, and outputting individual multiplexed series of demodulated data;
(2) a second multiple puncturing pattern generation means for generating puncturing patterns, which are identical to the predetermined plural form of puncturing patterns generated by said first multiple puncturing pattern generation means;
(3) a first depuncturing means for depuncturing each of the series of demodulated data in quantity corresponding to the predetermined number of diversity receptions output from said first code division multiplex signal reception means by using the predetermined different form of puncturing patterns supplied by said second multiple puncturing pattern generation means, and outputting a plural number of series of depunctured data;
(4) a first compounding means for compounding the predetermined plural number of series of depunctured data output by said first depuncturing means, symbol by symbol in a unit of block, and outputting a result of compounding; and
(5) a first convolutional decoding means for convolution-decoding said result of compounding, and outputting a decoded data,
wherein said time-diversity transmission and reception system executes code division multiplex transmission and reception of a plurality of different series of error-correction code word obtained by puncturing and convolution-coding identical series of information data with the plurality of different forms of puncturing patterns.

9. The transmission and reception system according to claim 1 comprising a plurality of transmission devices for transmitting series of identical information data, and a receiving device for receiving a plurality of signals transmitted by said transmission devices, each of said plurality of transmission devices comprising:

(1) a second convolutional coding means for convolution-coding and outputting said series of identical information input data;
(2) a first puncturing pattern generation means for generating a puncturing pattern having an identical puncturing rate, but different in block pattern from a puncturing pattern generated in any other of said plurality of transmission devices;
(3) a second puncturing means for puncturing a series of convolution-coded data output by said second convolutional coding means by using the puncturing pattern supplied by said first puncturing pattern generation means, and outputting a series of punctured data;
(4) a first transmission control means for out-

putting information of a predetermined transmission timing and a predetermined transmission frequency for said transmission device to execute a transmission; and

(5) a first modulation / transmission means for modulating and transmitting said series of punctured data in response to said information of transmission timing and transmission frequency, and

said receiving device comprising:

(1) a first reception control means for supplying information of a predetermined reception timing and a predetermined reception frequency for carrying out reception of individual signals transmitted by said plurality of transmission devices in said predetermined transmission timing and said predetermined transmission frequency;

(2) a first reception / demodulation means for receiving and demodulating the signal transmitted by each of said transmission devices in response to information of said predetermined reception timing and said predetermined reception frequency supplied from said first reception control means, and outputting individual series of demodulated data;

(3) a third multiple puncturing pattern generation means for generating a plural form of puncturing patterns, which are identical to the individual puncturing patterns of said plurality of transmission devices;

(4) a second depuncturing means for depuncturing each of the series of demodulated data output by said first reception / demodulation means by using a puncturing pattern that is identical to the one used by said transmission device among said predetermined plural form of puncturing patterns supplied from said third multiple puncturing pattern generation means, and outputting individual series of depunctured data;

(5) a second compounding means for compounding said plural series of depunctured data output by said second depuncturing means, symbol by symbol in a unit of block, and outputting a result of compounding; and

(6) a second convolutional decoding means for convolution-decoding said result of compounding,

wherein said transmission and reception system sets said transmission frequencies approximately equal and selects said transmission timings in a such manner not to overlap among said plurality of transmission devices in advance with said first transmission control means, and executes transmissions in different timings with one another by punctured-convolution-coding said series of identical information data individually with different puncturing patterns when transmitting said series of identical information data by said plurality of transmission devices.

10. The transmission and reception system according to claim 9, wherein:

(1) said first transmission control means in said plurality of transmission devices are replaced by second transmission control means, in which transmission timings are set to be approximately equal and transmission frequencies are selected in a such manner not to overlap among said plurality of transmission devices, in advance; and

(2) said first reception control means in said reception device is replaced by a second reception control means, in which reception timings and reception frequencies are set in advance to correspond with said transmission timings and said transmission frequencies of said second transmission control means.

11. The transmission and reception system according to claim 9, wherein:

(1) said first transmission control means in said plurality of transmission devices are replaced by third transmission control means, in which both transmission timings and transmission frequencies are set in advance in a such manner not to overlap among said plurality of transmission devices; and

(2) said first reception control means in said reception device is replaced by a third reception control means, in which reception timings and reception frequencies are set in advance to correspond with said transmission timings and said transmission frequencies of said third transmission control means.

12. The transmission and reception system according to claim 9, wherein:

(1) said first transmission control means in said plurality of transmission devices are replaced by fourth transmission control means, in which both transmission timings and transmission frequencies are set in advance to be approximately equal among said plurality of transmission devices;

(2) said first modulation / transmission means are replaced by second code division multiplex signal transmission means for modulating and transmitting said series of punctured data output by said second puncturing means with code division multiplexing in response to information of transmission timings and transmission frequencies supplied from said fourth transmission control means;

(3) said first reception control means in said reception device is replaced by a fourth reception control means, in which reception timings and reception frequencies are set in advance to correspond with said transmission timings and said transmission frequencies of said fourth transmission control means; and

(4) said first reception / demodulation means is replaced by a second code division multiplex signal reception means for receiving and demodulating a plurality of transmission signals transmitted with said code-division multiplexing by way of a despreading process according to information of said reception timings and said reception frequencies supplied from said fourth reception control means, and outputting an individual series of extracted demodulated data.

13. The transmission and reception system according to claim 1, comprising a transmission device, a plurality of receiving devices for receiving a signal output by said transmission device, and an output processing device for accumulating series of data received in said plurality of receiving devices, said transmission device comprising:

(1) a third convolutional coding means for outputting a series of input data by convolution-coding said series of data;

(2) a fourth multiple puncturing pattern generation means for generating and outputting a predetermined plural form of puncturing patterns having an identical puncturing rate, but different in block pattern of puncturing with one another;

(3) a third puncturing means for puncturing a series of convolution-coded data output by said third convolutional coding means by using each of said predetermined plural form of puncturing patterns supplied by said fourth multiple puncturing pattern generation means, and outputting a predetermined plurality of different series of punctured data;

(4) a fifth transmission control means for outputting information of a predetermined transmission timing and a predetermined transmission frequency for said transmission device; and

(5) a second modulation / transmission means for modulating and transmitting each of said predetermined plurality of different series of punctured data supplied from said third puncturing means in response to the information of said transmission timing and said transmission frequency,

each of said plurality of receiving devices comprising:

(1) a fifth reception control means for outputting information of a predetermined transmission timing and a predetermined transmission frequency for carrying out reception of individual transmission signals addressed to each of said receiving devices out of a plurality of signals transmitted by said transmission device in said predetermined transmission timing and said predetermined transmission frequency;

(2) a second reception / demodulation means for executing reception and demodulation according to information of said predetermined reception timing and said predetermined reception frequency supplied from said fifth reception control means, and outputting a series of demodulated data;

(3) a second puncturing pattern generation means for generating a puncturing pattern, which is identical to the one used in the transmission addressed to each of said receiving devices out of said predetermined plural form of puncturing patterns generated by said fourth multiple puncturing pattern generation means; and

(4) a third depuncturing means for depuncturing said series of demodulated data by using the puncturing pattern supplied by said second puncturing pattern generation means, and outputting a series of depunctured data, and

said output processing device comprising:

(1) a third compounding means for compounding said series of depunctured data obtained by each of said plurality of receiving devices, symbol by symbol in a unit of block; and

(2) a third convolutional decoding means for convolution-decoding a result of compounding output by said third compounding means,

wherein the information of said transmission timings supplied by said fifth transmission control means are arranged in a such manner that said

individual transmissions do not overlap, and that the information of said transmission frequency are approximately equal among said individual transmissions.

14. The transmission and reception system according to claim 13, wherein:

(1) said fifth transmission control means in said transmission device is replaced by a sixth transmission control means, in which individual transmission timings are set to be approximately equal and transmission frequencies are selected in a such manner not to overlap among individual transmissions of a predetermined number of times, in advance; and
(2) said fifth reception control means in said plurality of receiving devices are replaced by sixth reception control means, in which reception timings and reception frequencies for each of said receiving devices are set in advance to correspond with said transmission timings and said transmission frequencies assigned for individual receiving devices in said sixth transmission control means.

15. The transmission and reception system according to claim 13, wherein:

(1) said fifth transmission control means in said transmission device is replaced by a seventh transmission control means, in which both transmission timings and transmission frequencies are set in advance in a such manner not to overlap among individual transmissions of a predetermined number of times; and
(2) said fifth reception control means in said plurality of reception devices are replaced by seventh reception control means, in which reception timings and reception frequencies for each of said reception devices are set in advance to correspond with said transmission timings and said transmission frequencies assigned to each of said reception devices in said seventh transmission control means.

16. The transmission and reception system according to claim 13, wherein:

(1) said fifth transmission control means in said transmission device is replaced by an eighth transmission control means, in which both transmission timings and transmission frequencies are set in advance to be approximately equal among individual transmissions of a predetermined number of times;
(2) said second modulation / transmission means is replaced by a third code division multiplex signal transmission means for modulating and transmitting said predetermined plurality of different series of punctured data with code division multiplexing in response to information of transmission timings and transmission frequencies supplied from said eighth transmission control means;
(3) said fifth reception control means are replaced by eighth reception control means, in which reception timing and reception frequency for each of said reception devices are set in advance to correspond with said transmission timings and said transmission frequencies of said eighth transmission control means; and
(4) said second reception / demodulation means are replaced by third code division multiplex signal reception means for receiving and demodulating said signals transmitted with code-division multiplexing by extracting only a signal addressed to each of said receiving devices according to information of the predetermined reception timings and the predetermined reception frequencies supplied from said eighth reception control means, and outputting a series of demodulated data.

17. A satellite-path diversity transmission and reception system according to claim 1, comprising a transmission earth station, a receiving earth station, and a plurality of satellite repeater stations, wherein communication is made from said transmission earth station to said receiving earth station via said plurality of satellite repeater stations, said transmission earth station being provided with an earth station transmission device comprising:

(1) a fourth convolutional coding means for outputting a series of input data by convolution-coding said series of data;
(2) a fifth multiple puncturing pattern generation means for generating a predetermined plural form of puncturing patterns having an identical puncturing rate, but different in block pattern of puncturing with one another;
(3) a fourth puncturing means for puncturing a series of convolution-coded data output by said fourth convolutional coding means by using each of said predetermined plural form of puncturing patterns supplied by said fifth multiple puncturing pattern generation means, and outputting a predetermined plurality of different series of punctured data; and
(4) an earth station modulation / transmission means for transmitting each of said predetermined plurality of different series of punctured data to said plurality of satellite repeater stations, one series of data after another, and

said receiving earth station being provided with an earth station receiving device comprising:

(1) an earth station reception / demodulation means for receiving individual signals transmitted from said transmission earth station via said plurality of satellite repeater stations, and outputting individual series of demodulated data;
(2) a sixth multiple puncturing pattern generation means for generating a predetermined plural form of puncturing patterns, which are identical to the puncturing patterns of said fifth multiple puncturing pattern generation means;
(3) a fourth depuncturing means for depuncturing each of said predetermined plurality of different series of demodulated data output from said earth station reception / demodulation means by using each of said predetermined plurality of different puncturing patterns supplied by said sixth multiple puncturing pattern generation means, and outputting the plural number of series of depunctured data;
(4) a fourth compounding means for compounding the predetermined plural number of series of depunctured data output by said fourth depuncturing means, symbol by symbol in a unit of block, and outputting a result of compounding; and
(5) a fourth convolutional decoding means for convolution-decoding said result of compounding output by said fourth compounding means, and outputting a decoded data,
wherein said satellite-path diversity transmission and reception system punctured-convolution-codes identical series of information data with different forms of puncturing patterns, and executes path-diversity transmission and reception of an obtained plurality of different series of error-correction code word, as individual diversity branch data via said plurality of satellite repeater stations.

18. The satellite-path diversity transmission and reception system according to claim 1, comprising a plurality of earth stations and a plurality of satellite repeater stations, wherein said plurality of earth stations communicate with one another via said plurality of satellite repeater stations, and each of said plurality of earth stations comprises both of the earth station transmission device and the earth station reception device as recited in claim 17.

19. A transmission device comprising:

(1) a convolutional coding means for convolution-coding a series of input data, and outputting a series of convolution-coded data;
(2) a puncturing means for puncturing said series of convolution-coded data by using a plural form of puncturing patterns individually, and outputting a plurality of series of punctured data; and
(3) a modulation / transmission means for modulating and transmitting said plurality of series of punctured data.

20. A receiving device comprising:

(1) a reception / demodulation means for receiving and demodulating a signal transmitted by a transmission source via a communication pathway, and outputting a plural variety of series of demodulated data;
(2) a depuncturing means for depuncturing said plural variety of series of demodulated data individually by using puncturing patterns that are identical to what have been used by said transmission source, and outputting a plural variety of series of depunctured data;
(3) a compounding means for compounding said plural variety of series of depunctured data, and outputting a result of compounding; and
(4) a convolutional decoding means for convolution-decoding said result of compounding, and outputting a decoded data.

21. A transmission and reception device comprising a transmitter and a receiver, said transmitter comprising:

(1) a convolutional coding means for convolution-coding a series of input data, and outputting a series of convolution-coded data;
(2) a puncturing means for puncturing said series of convolution-coded data by using a plural form of puncturing patterns individually, and outputting a plurality of series of punctured data; and
(3) a modulation / transmission means for modulating and transmitting said plurality of series of punctured data, and
said receiver comprising:

(1) a reception / demodulation means for receiving and demodulating a signal transmitted by a transmission source via a communication pathway, and outputting a plural variety of series of demodulated data;
(2) a depuncturing means for depuncturing said plural variety of series of demodulated

data individually by using puncturing patterns that are identical to what have been used by said transmission source, and outputting a plural variety of series of depunctured data;

(3) a compounding means for compounding said plural variety of series of depunctured data, and outputting a result of compounding; and

(4) a convolutional decoding means for convolution-decoding said result of compounding, and outputting a decoded data.

22. A method of transmission and/or reception comprising at least either one of a process (a) or a process (b), said process (a) comprising the steps of:

(1) convolution-coding a series of input data, and outputting a series of convolution-coded data;

(2) puncturing said series of convolution-coded data by using a plural form of puncturing patterns individually, and outputting a plurality of series of punctured data; and

(3) modulating and transmitting said plurality of series of punctured data via at least one communication pathway, and

said process (b) comprising the steps of:

(1) receiving and demodulating a signal transmitted via said communication pathway, and outputting a plural variety of series of demodulated data;

(2) depuncturing said plural variety of series of demodulated data by using puncturing patterns that are identical to said plural form of puncturing patterns used in said step of puncturing, and outputting a plural variety of series of depunctured data;

(3) compounding said plural variety of series of depunctured data, and outputting a result of compounding; and

(4) convolution-decoding said result of compounding, and outputting a decoded data.

FIG. 1A

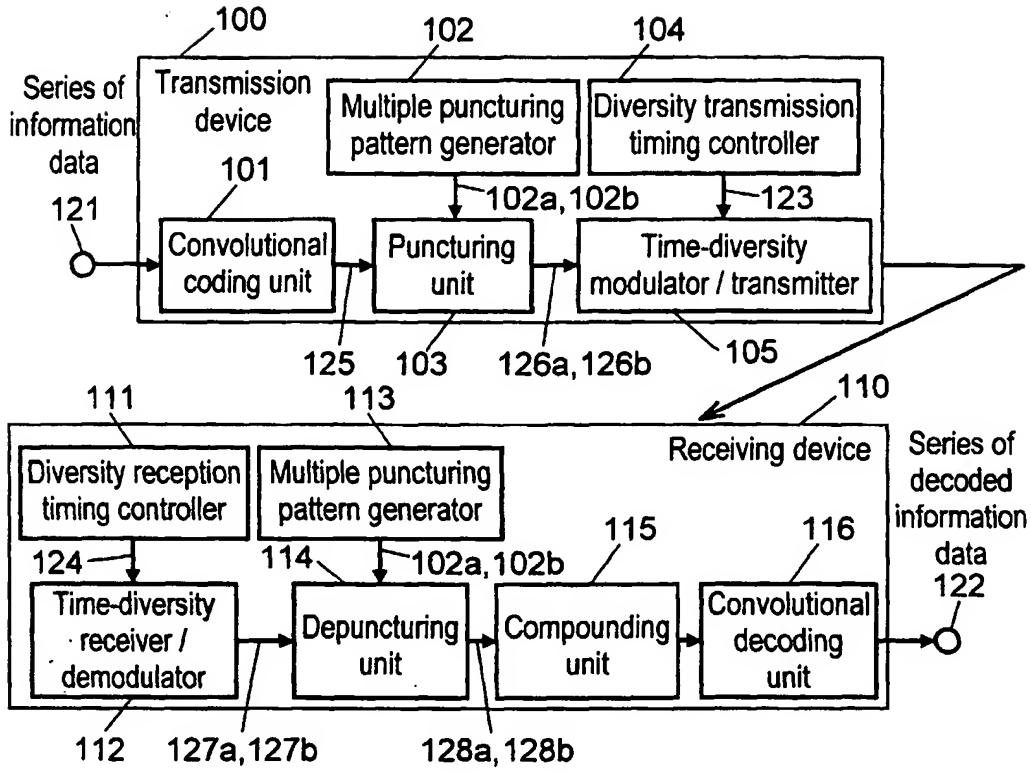

100
102
104
Series of information data
Transmission device
Multiple puncturing pattern generator
Diversity transmission timing controller
101
121
102a,102b
123
Convolutional coding unit
Puncturing unit
Time-diversity modulator / transmitter
125
103
126a,126b
105
111
113
110
Receiving device
Series of decoded information data
122
Diversity reception timing controller
Multiple puncturing pattern generator
124
114
102a,102b
115
116
Time-diversity receiver / demodulator
Depuncturing unit
Compounding unit
Convolutional decoding unit
112
127a,127b
128a,128b

FIG. 1B

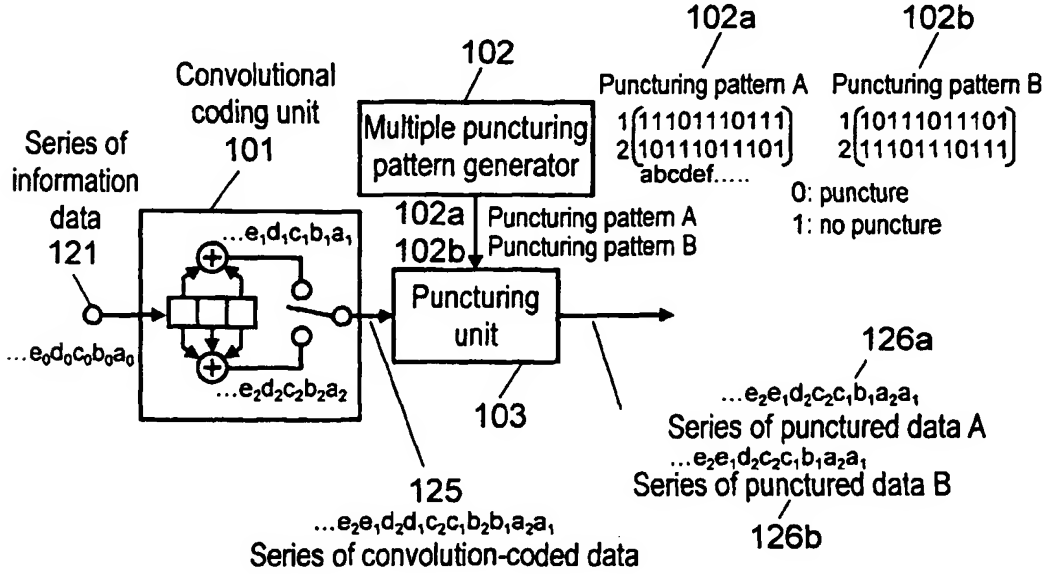

102a
102b
102
Puncturing pattern A
Puncturing pattern B
Convolutional coding unit
101
Multiple puncturing pattern generator
1 11101110111
2 10111011101
abcdef.....
1 10111011101
2 11101110111
0: puncture
1: no puncture
Series of information data
121
102a
102b
Puncturing pattern A
Puncturing pattern B
...e1d1c1b1a1
...e0d0c0b0a0
...e2d2c2b2a2
Puncturing unit
126a
...e2e1d2c2c1b1a2a1
Series of punctured data A
103
...e2e1d2c2c1b1a2a1
Series of punctured data B
125
...e2e1d2d1c2c1b2b1a2a1
Series of convolution-coded data
126b

FIG. 2A

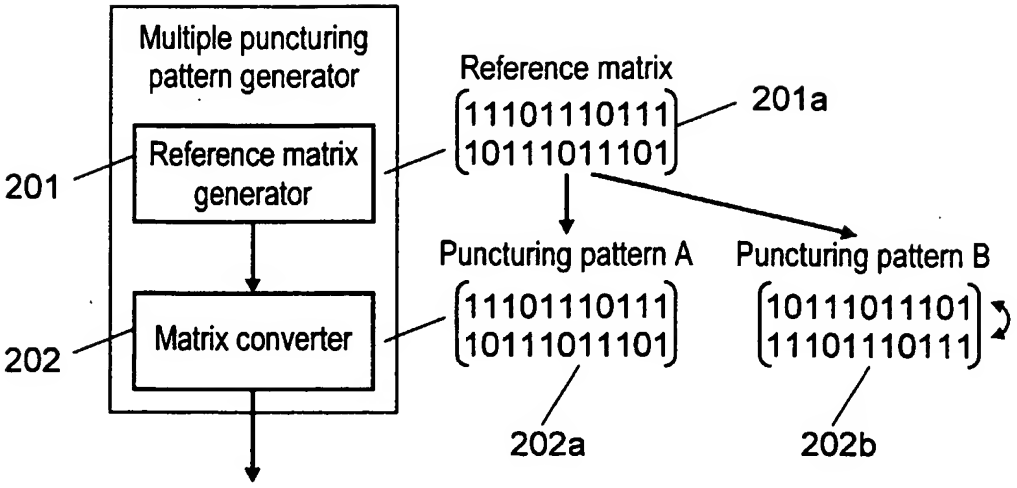

Multiple puncturing pattern generator
Reference matrix generator
Matrix converter
201
202
Reference matrix
11101110111
10111011101
201a
Puncturing pattern A
11101110111
10111011101
202a
Puncturing pattern B
10111011101
11101110111
202b

FIG. 2B

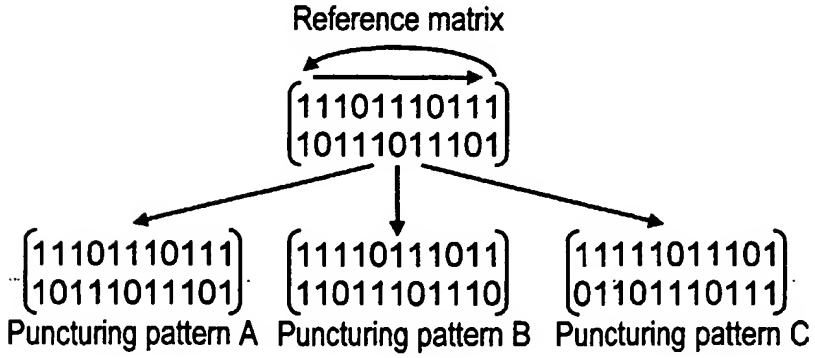

Reference matrix
11101110111
10111011101
11101110111
10111011101
Puncturing pattern A
11110111011
11011101110
Puncturing pattern B
11111011101
01101110111
Puncturing pattern C

FIG. 3

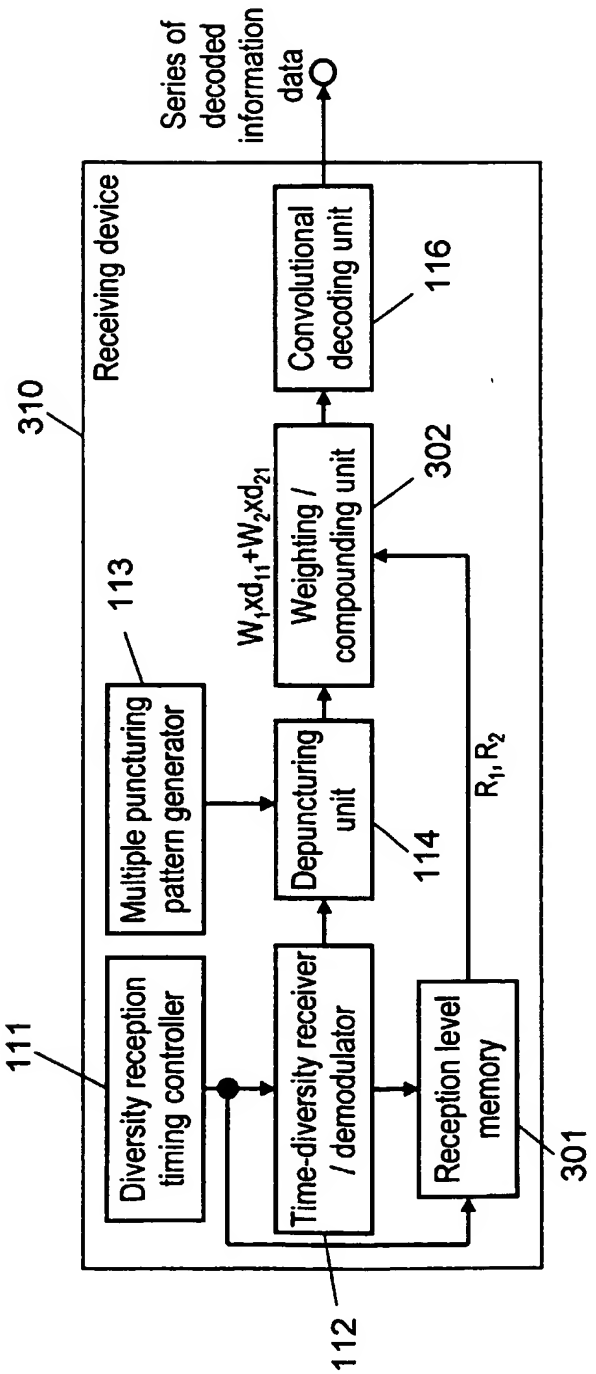

Series of decoded information data
Receiving device
310
Convolutional decoding unit
116
Weighting / compounding unit
302
$W_1xd_{11}+W_2xd_{21}$
Depuncturing unit
114
Multiple puncturing pattern generator
113
Diversity reception timing controller
111
Time-diversity receiver / demodulator
Reception level memory
301
R_1, R_2
112

FIG. 4

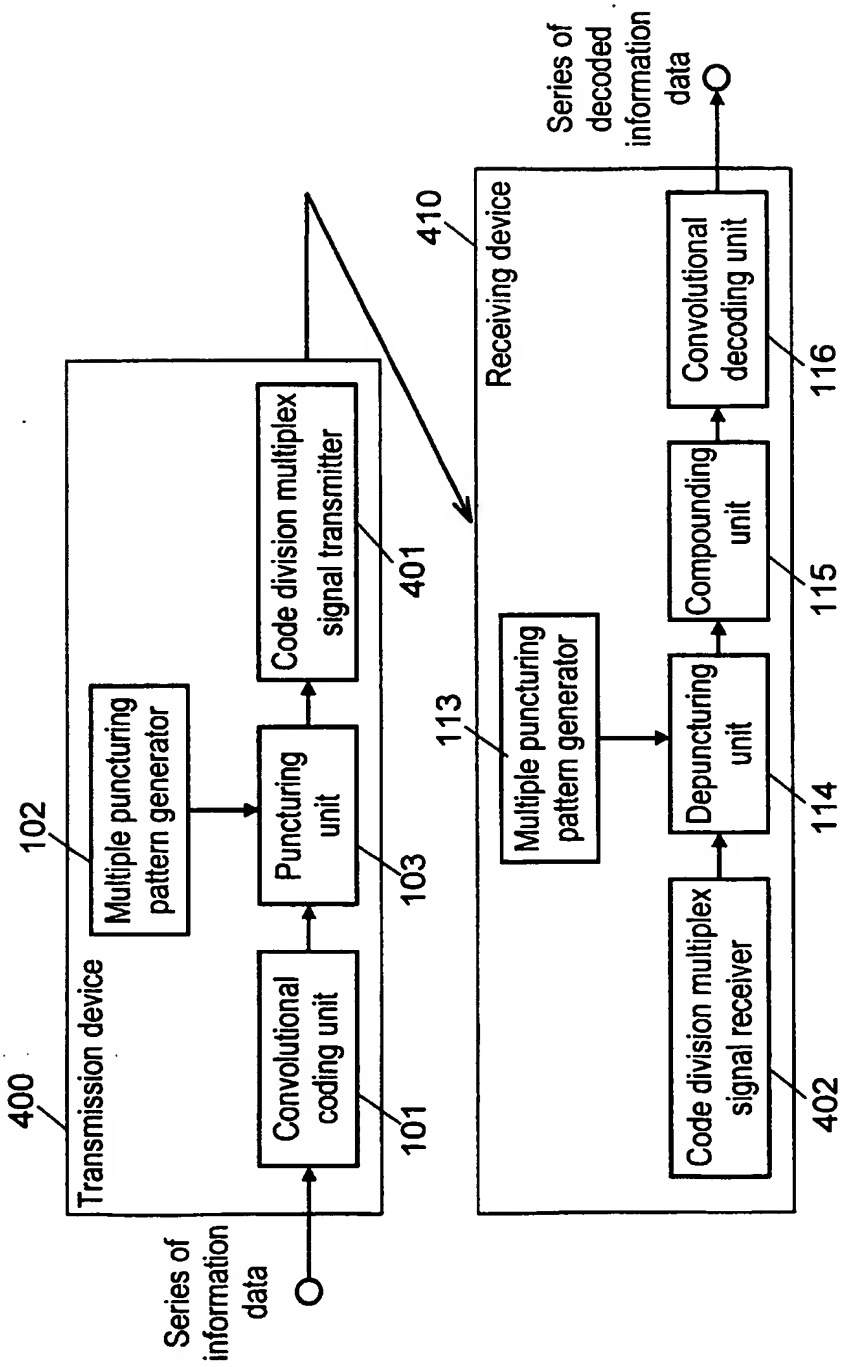

Series of information data
400
Transmission device
Convolutional coding unit
101
Puncturing unit
103
Multiple puncturing pattern generator
102
Code division multiplex signal transmitter
401
410
Receiving device
Code division multiplex signal receiver
402
Depuncturing unit
114
Multiple puncturing pattern generator
113
Compounding unit
115
Convolutional decoding unit
116
Series of decoded information data

FIG. 5

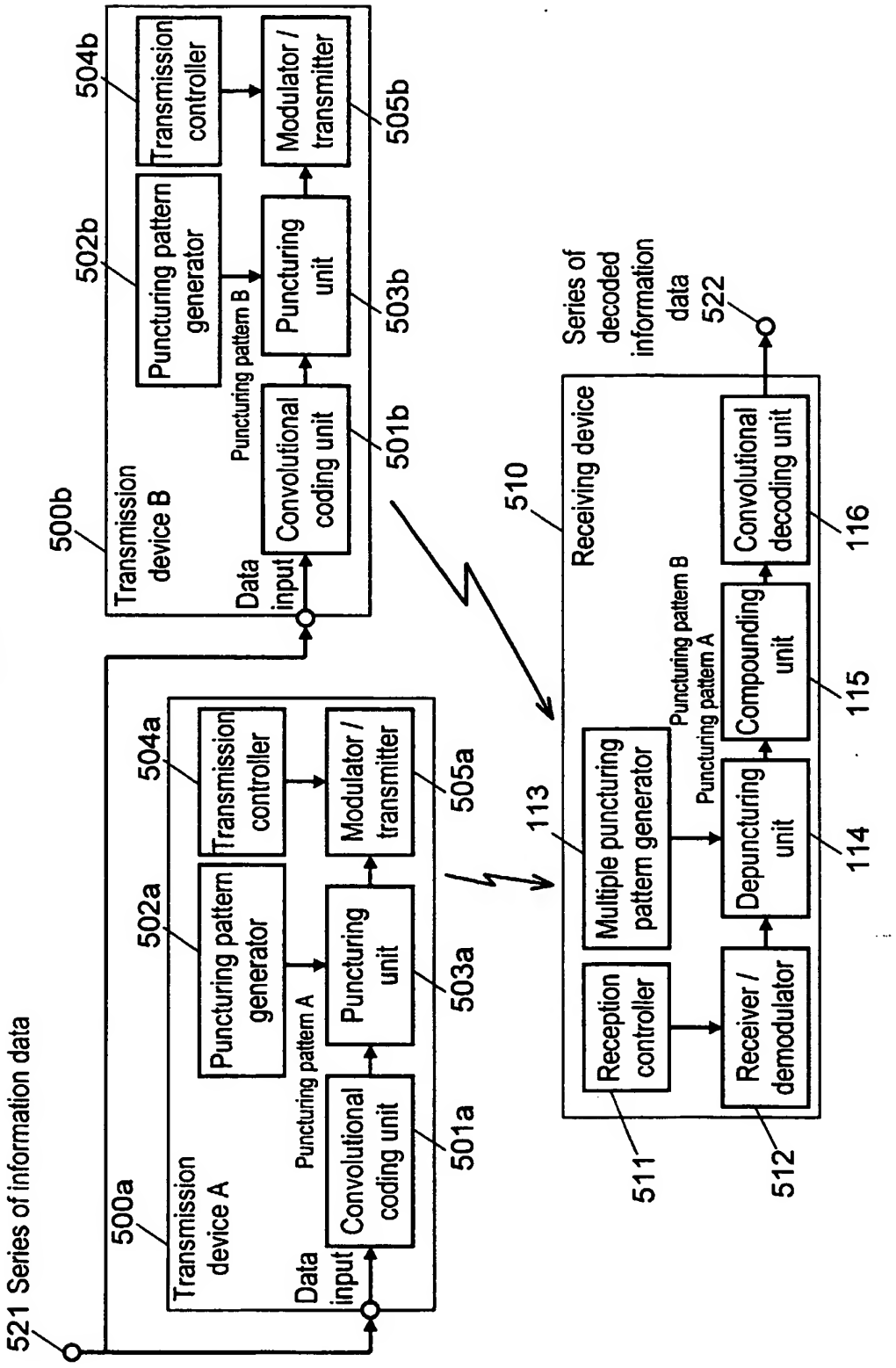

521 Series of information data
500a
Transmission device A
Data input
Convolutional coding unit
501a
Puncturing pattern A
Puncturing pattern generator
502a
Puncturing unit
503a
Transmission controller
504a
Modulator / transmitter
505a
500b
Transmission device B
Data input
Convolutional coding unit
501b
Puncturing pattern B
Puncturing pattern generator
502b
Puncturing unit
503b
Transmission controller
504b
Modulator / transmitter
505b
113
510
Receiving device
Reception controller
511
Receiver / demodulator
512
Multiple puncturing pattern generator
Puncturing pattern A
Puncturing pattern B
Depuncturing unit
114
Compounding unit
115
Convolutional decoding unit
116
Series of decoded information data
522

FIG. 6

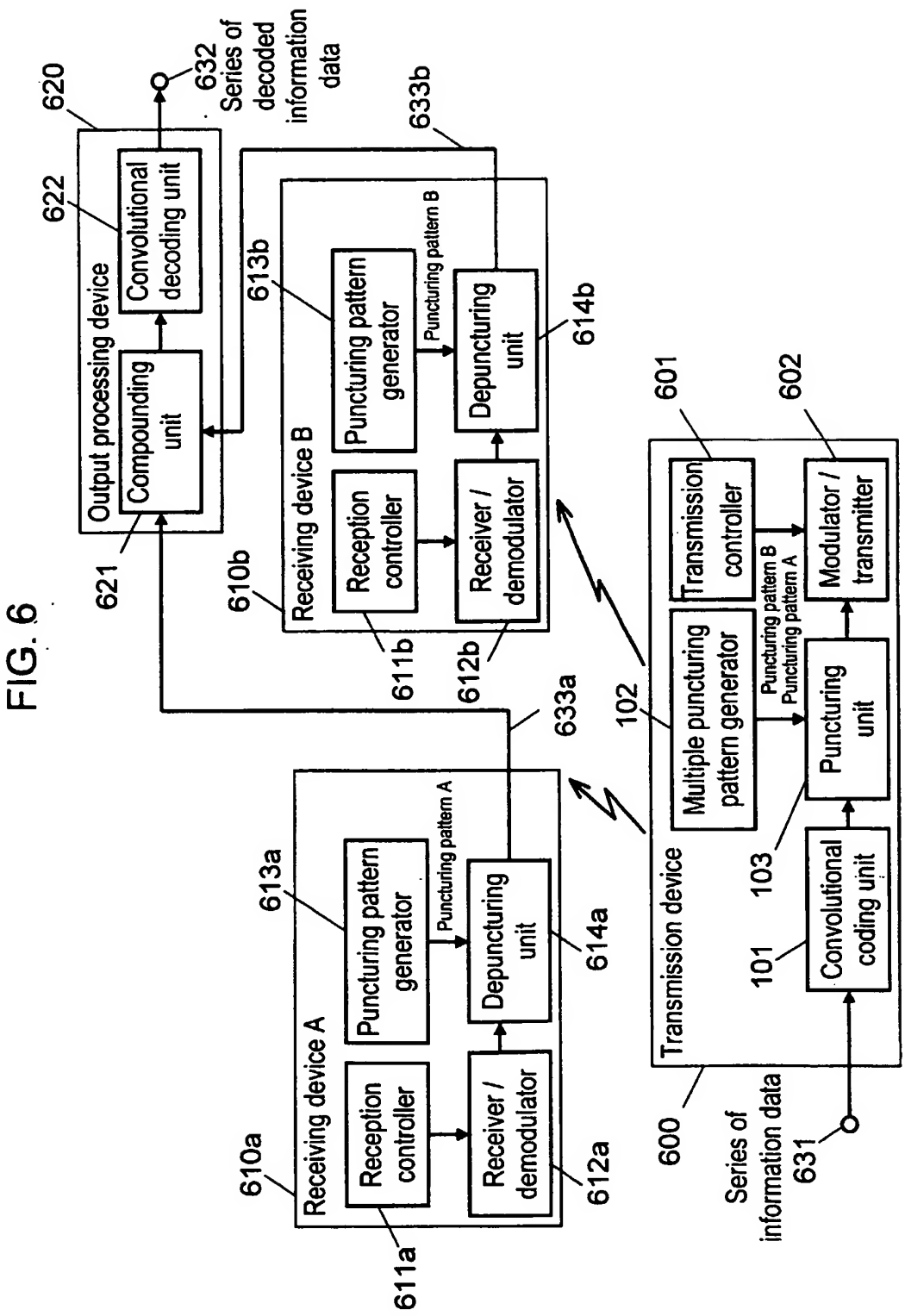

Transmission device
600
Series of information data
631
Convolutional coding unit
101
Puncturing unit
103
Multiple puncturing pattern generator
102
Puncturing pattern A
Puncturing pattern B
Transmission controller
601
Modulator / transmitter
602
Receiving device A
610a
Reception controller
611a
Receiver / demodulator
612a
Depuncturing unit
614a
Puncturing pattern generator
613a
Puncturing pattern A
633a
Receiving device B
610b
Reception controller
611b
Receiver / demodulator
612b
Depuncturing unit
614b
Puncturing pattern generator
613b
Puncturing pattern B
633b
Output processing device
620
Compounding unit
621
Convolutional decoding unit
622
632
Series of decoded information data

FIG. 7

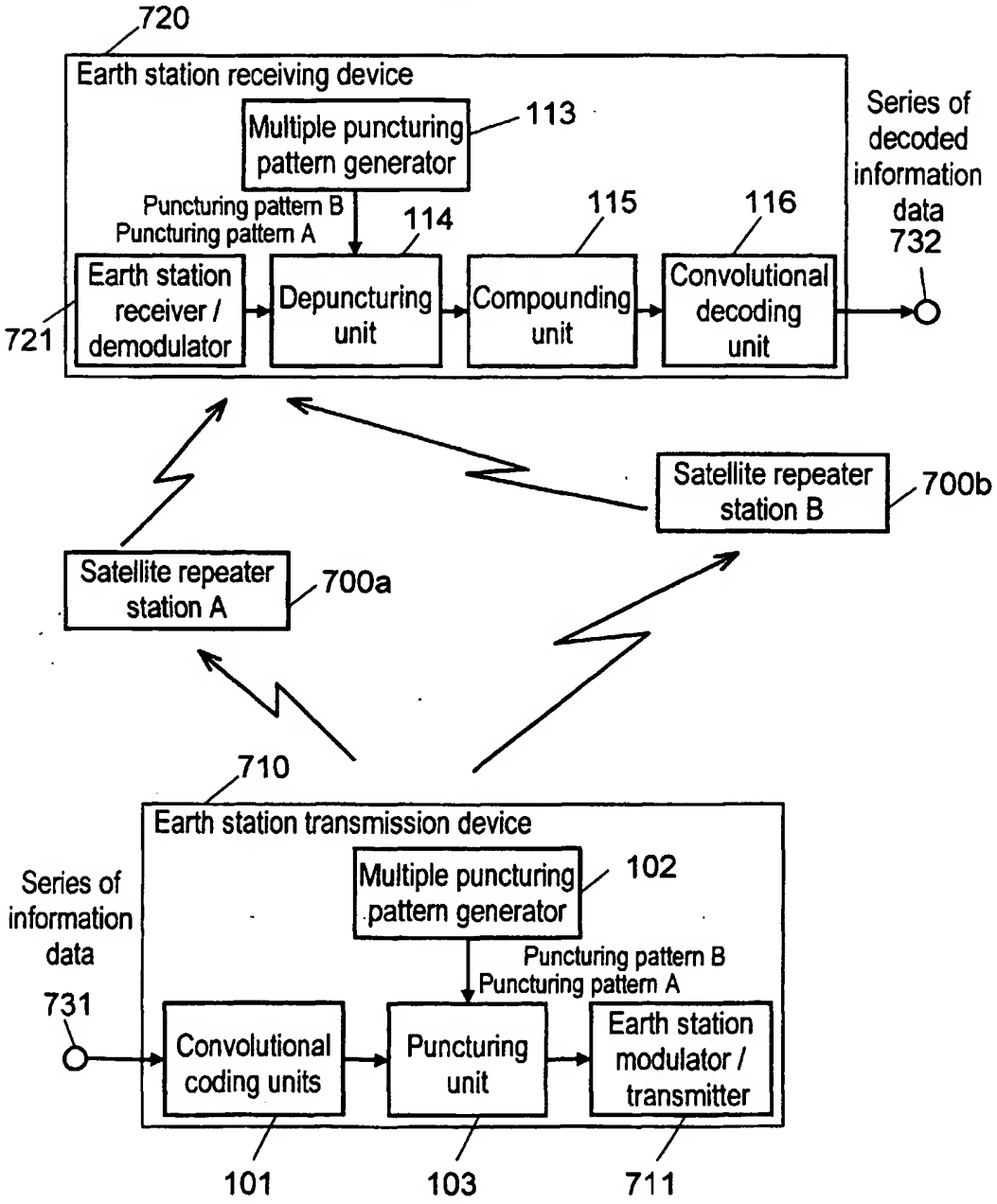

720
Earth station receiving device
Multiple puncturing pattern generator
113
Puncturing pattern B
Puncturing pattern A
114
115
116
Series of decoded information data
732
Earth station receiver / demodulator
721
Depuncturing unit
Compounding unit
Convolutional decoding unit
Satellite repeater station B
700b
Satellite repeater station A
700a
710
Earth station transmission device
Series of information data
731
Multiple puncturing pattern generator
102
Puncturing pattern B
Puncturing pattern A
Convolutional coding units
Puncturing unit
Earth station modulator / transmitter
101
103
711

FIG. 8A

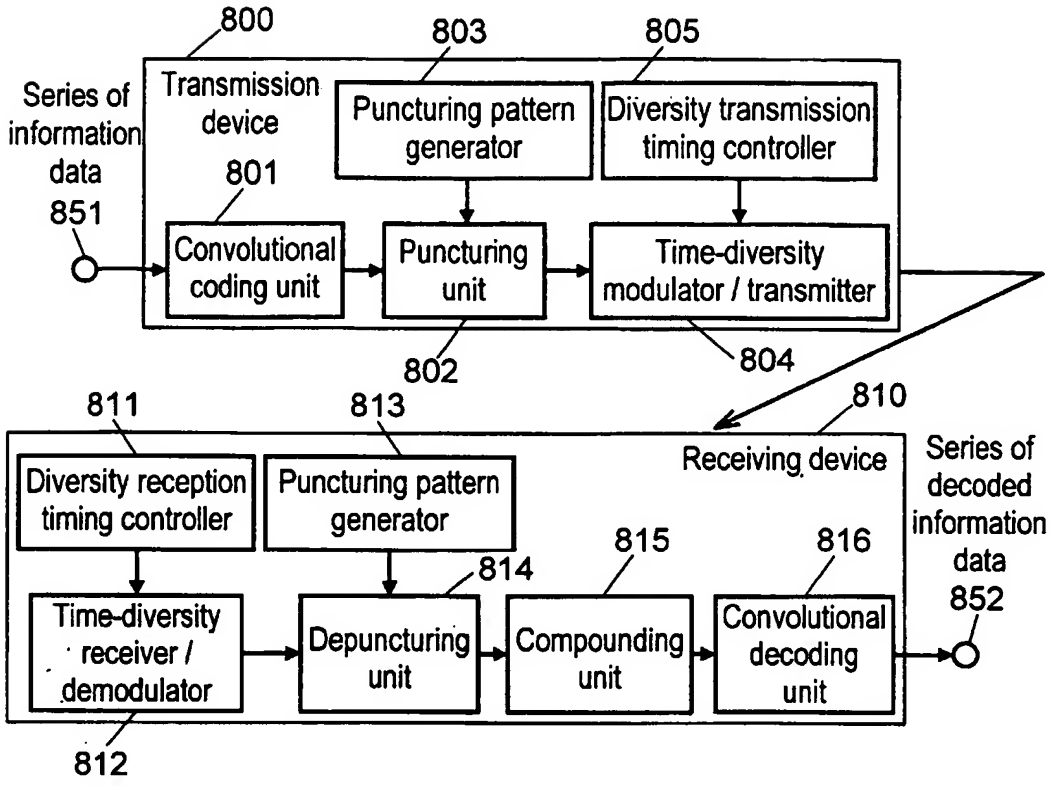
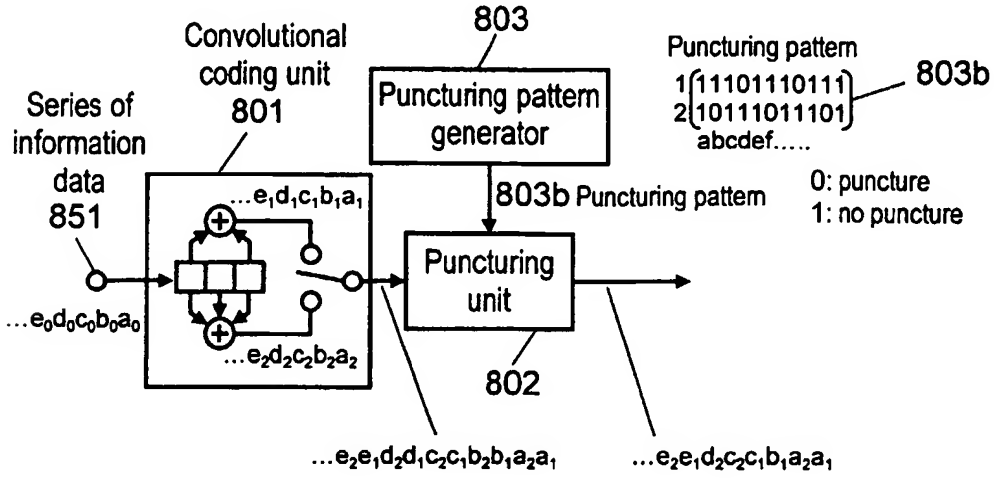

800
803
805
Series of information data
851
Transmission device
Puncturing pattern generator
Diversity transmission timing controller
801
Convolutional coding unit
Puncturing unit
Time-diversity modulator / transmitter
802
804
811
813
810
Receiving device
Diversity reception timing controller
Puncturing pattern generator
Series of decoded information data
852
815
816
814
Time-diversity receiver / demodulator
Depuncturing unit
Compounding unit
Convolutional decoding unit
812

FIG. 8B


803
Convolutional coding unit
801
Puncturing pattern generator
Puncturing pattern
1 11101110111
2 10111011101
abcdef.....
803b
Series of information data
851
...e1d1c1b1a1
803b Puncturing pattern
0: puncture
1: no puncture
Puncturing unit
...e0d0c0b0a0
...e2d2c2b2a2
802
...e2e1d2d1c2c1b2b1a2a1
...e2e1d2c2c1b1a2a1